Research on the Measurement and Evaluation of High-quality Development in Guangdong Province based on the TOSIS Method of Entropy Weight and Coupled Coordination Model

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Abstract

Based on a profound interpretation of the connotation of high-quality development, this paper constructs high-quality development indicators for the new era from the six major systems of innovation, coordination, green, openness, sharing, and effectiveness. It uses the TOSIS method of entropy weight and coupled coordination model to measure the comprehensive index of high-quality development and analyze the coupling coordination degree of six subsystems. The research results show that: (1) The high-quality development of Guangdong Province has achieved certain results from 2014 to 2020. Among them, innovation and openness have made a more outstanding contribution to the high-quality development of Guangdong Province. Especially in recent years, innovation has driven the economy strongly more than openness. But there are shortcomings in sharing and greenness. (2) There is a significant gap in the degree and speed of development between different regions in Guangdong province. The high-quality development of the Pearl River Delta region is better and faster than other regions. (3) In this paper, the physical coupling model is used to analyze the coordinated development of the six subsystems of high-quality development. The coupling coordination degree of high-quality development subsystems in the Pearl River Delta is significantly higher than that of other areas, and high-quality development comprehensive index and coupling coordination degree are positively correlated.

Keywords: *high-quality development, Guangdong Province, entropy weight method TOSIS, coupled coordination model*

1. INTRODUCTION

China's economic development has made remarkable achievements because of the reform and opening-up policy in 1978. The total GDP of Guangdong Province exceeds 11 trillion RMB, ranking first for 32 consecutive years. The economic development of Guangdong Province has achieved good results. Still, it is also facing some pressures such as unbalanced regional development, the widening gap between urban and rural areas, and the decline in the advantages of demographic dividends. Continuing to maintain development advantages and make up for shortcomings in Guangdong Province is a crucial problem that needs to be overcome to achieve better achievements. The report of the 19th National Congress of the Communist Party of China pointed out that China's economy has shifted from a stage of high-speed growth to a phase of high-quality development. The high-quality development of Guangdong in the new phase must adhere to the six dimensions of innovation, coordination, greenness, openness, sharing, and effectiveness.

2. LITERATURE REVIEW

Jian Xinhua (2020) constructs a high-quality development index system from five aspects and finds

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that China's high-quality development. The expansion rate of quality development lags economic growth.[1] Zhang Yanhong (2021) evaluates the level of rural integration development in Hunan and achieves remarkable results in the research and development of Hunan agricultural tourism.[2] Sun Hao (2020) constructs high-quality development indicators and measures the quality of China's regional economic development in 2017. The study finds that China's development has advantages in innovation, coordination, and green dimensions, and there are shortcomings in openness and sharing.[3] Ma Ru (2019) finds that the five indicators have shortcomings and inconsistencies in the eastern, central, and western regions.[4] Zhang Tao (2020) constructs a macro and micro integrated high-quality development measurement system including enterprise, industry, and regional levels.[5] Liu Rui (2020) constructs a high-quality development index based on five development concepts of innovation, coordination, greenness, openness, and sharing and measured the Northeast. The study finds a severe lack of openness in the Northeast.[6] Meng Xianglan (2018) constructs an indicator of high-quality economic development based on innovative growth, coordinated development and people's livelihood development. The study finds that in the process of high-quality development in Hubei.[7] Chen Xiaoxue (2019) constructs high-quality economic development indicators from the six dimensions of innovation, coordination, greenness, openness, sharing, and effectiveness. The study found that 30 provinces and cities have achieved certain achievements in high-quality development, but the gap between regions still exist.[8]

The scholars mentioned above have accumulated a lot of achievements in the construction and measurement of high-quality development indicators and conducted vertical and horizontal macro-research on China and 32 provinces and cities. Based on the results, this paper analyzes the regional characteristics of high-quality development with Guangdong Province as the research object.

3. INDICATORS AND MENTHODS

3.1. Indicators

This paper draws on Chen Xiaoxue's method to construct high-quality economic development indicators from the six dimensions of innovation, coordination, greenness, openness, sharing, and effectiveness. It sets up a "6-18" hierarchical structure in table 1 (6 primary indicators 18 secondary indicators index). The data comes from the 2014-2020 Guangdong Provincial Urban Statistical Yearbook. Innovation aims to adjust the driving force of economic growth, highlighting the contribution of knowledge and technological innovation to economic growth. Coordination means reducing the gap between urban and rural areas, coordinating consumption and investment, and more reasonable development of industrial institutions. Greenness emphasizes the harmonious development of nature, people, and the environment. Openness aims at China's future development to participate in the ranks of world economic globalization more actively. Sharing aims at narrowing the gap between the rich and the poor, and the results of development can benefit more people. The living standards of residents have effectively improved. Effectiveness aims to effectively achieve macroeconomic goals such as residents' income growth and employment stability during development.

3.2. Methods Introduction

In this paper, the above indicators construct to measure the high-quality development level of the economy. The entropy weight method derives from thermodynamics. The entropy value measures the degree of disorder and uncertainty of the system.

Table 1 The evaluation index system of high-quality development

Primary indicator	Secondary indicators	Nature
Innovation	Ratio of Value-Added Manufacturing of Advanced Industry to that of Industry (%)	positive
	Technology spending/general public budget spending (%)	positive
	Number of industrial enterprises above designated size (units)	positive
Coordination	Tertiary industry/GDP (%)	positive
	Per capita GDP of each city (ten thousand yuan/person)	positive
	Urban-rural consumption gap = urban per capita consumption/rural per capita consumption (%)	negative
Greenness	Growth rate of energy consumption per unit of GDP (%)	negative
	Growth rate of energy consumption per unit of industrial added value (%)	negative
	Harmless treatment rate of domestic waste (%)	positive
Openness	Number of foreign-invested enterprises (units)	positive
	Total investment by foreign-invested	positiv

	enterprises (US$100 million)	e
	Increase in loans of financial institutions/GDP (%)	positiv e
Sharing	Number of doctors per 10,000 people (person)	positiv e
	Number of people participating in primary medical care per 10,000 people (person)	positiv e
	Number of art troupes and library staff per 10,000 people (person)	positiv e
Effectiv eness	Annual disposable income of residents (yuan)	positiv e
	Total labor productivity (yuan/person)	positiv e
	Labor compensation/GDP (%)	positiv e

The weight determines according to the information of the data itself. Then the more orderly the system is, the less information it contains, the less contribution it makes in the evaluation, it is weightless. Conversely, the smaller the entropy value, the greater the disorder of the information, the more information it contains, the greater its role in the evaluation, and the greater the weight. Therefore, the weight calculated by the entropy weight method is more objective.

Since the entropy weight method determines the weight according to the information contained in the actual data, the results are more accurate and reasonable.[9] This paper selects the TOPSIS method of entropy weight to calculate the high-quality economic development index. The specific calculation process is as follows.

The first step is to standardize the variables.

$$Y_{tj}\begin{cases}\dfrac{X_{tj}-min(X_{tj})}{max(X_{tj})-min(X_{tj})} & X_{tj}is\ a\ positive\ indicator\\ \dfrac{max(X_{tj})-X_{tj}}{max(X_{tj})-min(X_{tj})} & X_{tj}is\ a\ negtive\ indicator\end{cases} \quad (1)$$

The second step is to calculate the information entropy e_j of the j indicators to ensure that the data is meaningful, we assume that whenY_{tj}=0, lnY_{tj}=0.

$$e_j = -\sum_{t=1}^{T}\left[\left(Y_{tj}/\sum_{t=1}^{T}Y_{tj}\right).\ln\left(Y_{tj}/\sum_{t=1}^{T}Y_{tj}\right)\right]/\ln T \quad (2)$$

The third step is to calculate the weight W_j of the j indicators, $W_j = (1-e_j)/\sum_{j=1}^{m}(1-e_j)$. (3)

The fourth step is to construct the weighted matrix Z of each indicator, $Z = (r_{tj})_{T\times m} = (W_j \times Y_{tj})_{T\times m}$. (4)

4. MEASUREMENT RESULTS AND ANALYSIS

4.1. IndicatorsMeasurement results of comprehensive index of high-quality development

This paper calculates the comprehensive index of high-quality economic development of 21 cities in Guangdong Province from 2014 to 2020. From the results of table 2, we find that: firstly, the high-quality economic development of Guangdong Province has been effectively improved, and the high-quality economic development has improved. The development comprehensive index has achieved positively growth. Secondly, the high-quality economic development level of the Pearl River Delta is significantly higher than other cities in Guangdong because the top eight cities belong to the Pearl River Delta region from 2017 to 2020. Lastly, we find that the score gap between the first and the last has gradually widened from 2014 to 2020, which means a significant imbalance in the level and speed of high-quality development in Guangdong Province.

Table 2 Calculation results of the comprehensive index of high-quality

City	2014	2015	2016	2017	2018	2019	2020
Shenzhen	397	429	508	549	641	681	668
Guangzhou	330	356	353	570	631	662	683
Dongguan	228	239	246	271	294	320	333
Zhuhai	215	235	277	289	288	316	313
Foshan	199	204	232	258	280	332	334
Zhongshan	171	179	215	231	231	245	227
Jiangmen	156	161	171	155	166	176	181
Huizhou	139	142	161	202	213	223	221
Zhaoqing	118	118	123	118	134	140	141
Maoming	106	103	109	131	145	143	154
Zhanjiang	145	148	144	122	133	128	141
Yangjiang	88	90	96	98	103	123	121
Qingyuan	92	100	100	104	110	123	126
Shaoguan	123	126	128	111	111	122	133
Heyuan	100	97	105	113	123	123	132
Meizhou	106	112	115	108	119	123	131
Yunfu	77	81	78	86	86	93	101
Jieyang	104	109	119	95	106	102	104
Shanwei	113	114	128	89	91	87	111
Shantou	83	90	99	113	121	120	124
Chaozhou	70	68	68	78	83	89	93

Note: The Pearl River Delta includes Guangzhou, Shenzhen, Dongguan, Zhuhai, Zhongshan, Foshan, Jiangmen, Huizhou, and Zhaoqing.

4.2. Measurement results of six subsystems' average index

We calculate the six indexes for each city separately to analyze the specific development of each city's six subsystems, and we aggregate the averages of the six indexes by region for simplicity. Comparing with each index of α in table 3, we find openness and innovation in promoting the high-quality development economy have made a high contribution in the Pearl River Delta. We notice that with the external environment of the global economic downturn, innovation has exceeded openness after 2018. The high-quality economic development of the Pearl River Delta has shortcomings in sharing and green.

Table 3 The average index of six subsystems in the Pearl River Delta

and non-Pearl River Delta

Zj	regio n	2014	2015	2016	2017	2018	2019	2020
Z1	α	91	28	87	90	93	97	107
	β	57	28	54	51	52	60	57
Z2	α	50	51	51	57	58	60	53
	β	34	35	36	36	38	40	36
Z3	α	32	25	26	36	32	45	40
	β	32	24	24	30	28	41	38
Z4	α	116	126	117	98	101	93	95
	β	61	62	56	48	50	45	47
Z5	α	55	47	42	48	29	39	32
	β	52	44	41	40	36	33	36
Z6	α	92	79	76	79	82	80	77
	β	69	54	51	50	52	50	50

Note: Z1 means Innovation, Z2 means coordination, Z3 means Greenness, Z4 means Openness, Z5 means Sharing, Z6 means Effectiveness. αrefers to the average index of The Pearl River Delta. β refers to the average index of other regions.

Comparing with each index of α and β we find six subsystems' average indexes in Guangdong Province are unbalanced, and the Pearl River Delta and other regions are largely unbalanced in innovation and openness. The differences in innovation are getting bigger and bigger. In 2020, the average value of the innovation index of the Pearl River Delta is five times that of the other regions. And the average index of openness of the Pearl River Delta is about nine times that of other areas. But the gap in greenness and sharing is around 2, mainly because they are the two significant shortcomings of the Pearl River Delta region.

4.3. Calculation of the coupling degree development of six subsystems

This paper introduces the capacity coupling coefficient model in physics to measure the degree of coupling between subsystems and the degree of coupling between six subsystems with high-quality development. Firstly, the indexes of the six subsystems are calculated annually by the entropy weight method.

$C_t = \frac{K\left(Z_{t_1} \times Z_{t_2} \times \ldots \times Z_{t_k}\right)^{1/K}}{\left(Z_{t_1} + Z_{t_2} + \ldots + Z_{t_k}\right)/K}$, Z_{t_K} is the subsystem index of k in the year t, C_t represents the degree of coupling degree, $C_t \in [0,1]$。The greater the coupling degree, the stronger the interaction between the systems.

Secondly, we need to calculate the D_t which is the coupling coordination degree of the six subsystems, $D_t = \sqrt{C_t \times G_t}$, $G_t = \alpha_1 Z_{1t} + \alpha_2 Z_{2t} + \ldots + \alpha_K Z_{Kt}$, α_K indicates the importance of the high-quality development subsystem index , $\alpha_1 + \alpha_2 + \ldots + \alpha_K = 1$. Existing research usually uses the uniform weighting method to determine α_K, this paper selects $\alpha_1 = \alpha_2 = \ldots = \alpha_K = \frac{1}{6}$。

This paper draws on Wang Yi's classification method and uses 0.2 as a step to divide the coupling degree into five levels: excellent, good, medium, weak, and poor.[10]

Table 4 Calculation of the coupling degree development of six subsystems in Guangdong Province

Year / City	2014	2015	2016	2017	2018	2019	2020	level (2020)
Shenzhen	78	74	77	80	76	82	79	Good
Guangzhou	75	72	69	78	74	81	78	Good
Dongguan	65	65	60	56	59	57	52	Medium
Zhuhai	62	61	62	67	56	66	63	Good
Foshan	61	55	55	57	55	56	56	Medium
Zhongshan	43	41	42	55	52	52	48	Medium
Jiangmen	54	52	50	46	45	48	46	Medium
Huizhou	53	51	49	49	48	51	49	Medium
Zhaoqing	46	39	39	39	43	39	40	Poor
Maoming	44	37	38	36	41	41	42	Medium
Zhanjiang	47	45	36	33	40	38	38	Poor
Yangjiang	36	34	35	33	34	39	36	Poor
Qingyuan	44	41	38	39	39	41	40	Poor
Shaoguan	49	44	41	38	37	44	41	Medium
Heyuan	41	41	39	41	42	42	39	Poor
Meizhou	44	40	40	41	38	33	38	Poor
Yunfu	33	32	30	34	34	31	34	Poor
Jieyang	39	37	34	28	33	28	30	Poor
Shanwei	42	33	38	28	27	33	35	Poor
Shantou	42	41	38	37	40	40	35	Poor

Chaozhou	39	28	25	23	24	30	29	Poor

Note: The Pearl River Delta includes Guangzhou, Shenzhen, Dongguan, Zhuhai, Zhongshan, Foshan, Jiangmen, Huizhou, and Zhaoqing.

We find the coupling degree of the six subsystems in the Pearl River Delta is still improving, and there are few cities with a reasonable degree of coordination in the table 4. Cities in the non-Pearl River Delta region are all at a weak level of coordination. The coupling degree of the six subsystems is positively correlated with the comprehensive index of high-quality development. The coupling degree of the non-Pearl River Delta region is lower than that of the Pearl River Delta region，so the coupling coordination degree is positive with the comprehensive high-quality development index. At the same time, except for Shenzhen, Guangzhou, and Zhuhai, the coupling degree between subsystems in most cities showed a downward trend from 2014 to 2020, which shows that the incoordination of subsystems exists in most cities in Guangdong Province.

5. CONCLUSION

High-quality development is the essential requirement for economic development in Guangdong Province. Based on the data from 2014 to 2020, this article uses the entropy weight method TOSIS to calculate the comprehensive index of high-quality development in Guangdong Province. The contribution of subsystems is analyzed, and the coupling coordination degree of subsystem coordination is measured. The research results show that: Firstly, the high-quality economic development of Guangdong Province has been effectively improved, innovation and openness have made a more outstanding contribution, but there are shortcomings in sharing and greenness. Secondly, there are obvious regional incoordination problems in the development of Guangdong. The Pearl River Delta's high-quality economic development level and speed are markedly higher and faster than that of non-Pearl River Delta regions. Thirdly, there are regional gaps in developing the six indicators of high-quality development in Guangdong Province, with a significant imbalance in the two dimensions of innovation and openness and a small relative gap in sharing and greenness. The coupling degree of the six subsystems in the Pearl River Delta is relatively high positively correlated with the comprehensive index of high-quality development. The degree of coupling between subsystems in most cities has shown a downward trend from 2014 to 2020.

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